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United States Patent Application

of

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for

LOW-RUNNING-TEMPERATURE TYRE

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TITLE OF THE INVENTION

The title of this invention is "Low-Running-Temperature Tyre."

Sub A1

~~CROSS-REFERENCE TO RELATED APPLICATIONS~~

This application is a continuation of U.S. Patent Application Serial No. 09/472,019, filed December 27, 1999, which is a continuation ~~of~~ U.S. Patent Application Serial No. 09/041,951, filed March 13, 1998; ~~additionally,~~ Applicants claims the right of priority under 35 U.S.C. § 119(a) - (d) ~~based on~~ patent application No. MI97A 000584, filed March 14, 1997, in Italy; the ~~contents of all of which~~ are relied upon and incorporated herein ~~by reference.~~

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to tyres for mounting on vehicle wheels, and more particularly to tyres for motorcycles and cars, but it may also relate to any other type of tyres. More specifically, the invention pertains to the tread band used in tyres, which also includes raw or pre-molded treads for covering or "recapping" worn tyres, as well as to a method of achieving optimal thermal conditions during use of the tyre.

Description of the Related Art

It is known that today tyres must not only possess good performance features in terms of operating on any kind of road surfaces, i.e., dry, wet, or snow-covered surfaces, but also must have good qualities such as a comfortable and smooth ride and high mileage. These features must be maintained even when the tyre runs under critical or extreme conditions, due for

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example to high speed operation in connection with racing on a track, in particular in combination with a high ambient temperature.

These performance and operational features of the tyre are determined by grooves and circumferential and/or transverse hollows of appropriate sizes and orientation that are formed in the tread band. These elements give rise to ribs and/or blocks variously located in the tread band so as to form different designs of tread pattern, optimized according to the intended use for the tyre. In particular, said pattern can be defined as symmetric when it is always the same irrespective of the rolling direction of the tyre, asymmetric when one side of the tread band is different from the axially opposite side, and finally, directional when the tyre is designed to operate in a preferred rolling direction. In the last case, one side of the tread band is a mirror image of the other side, relative to the equatorial plane of the tyre.

Preferably, in particular for the purpose of obtaining good traction on wet or snow-covered road surfaces and on curvy roads, blocks and ribs are provided on the tread band to form an appropriate pattern. This pattern includes a series of narrow grooves of greater or lesser density or width, oriented in a direction substantially perpendicular to the direction of vehicle movement along which traction has to be provided.

It is known that the performance of the tyre is adversely affected to a great extent by the operating temperature of the tyre. One of the most difficult problems to be solved has always been and still is that of maintaining a good resistance to wear and appropriate grip at normal temperatures of operation of the tyre (30°C-50°C), as well as when the tyre exceeds those temperatures due to strong thermal and mechanical stresses, such as those resulting from use under so-called "extreme conditions."

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The difficulty in obtaining these desired features of the tyre under all operating condition essentially originates from the fact that resistance to wear and appropriate grip are two goals substantially incompatible with each other. For the tyre to achieve a good resistance to wear and low resistance to rolling, elastomeric blends having a low hysteresis value must be employed in forming the tyre tread band. However, these blends are capable of dissipating a limited amount of energy during rolling.

On the other hand, to achieve the desired tyre grip or traction, elastomeric blends of a high hysteresis value are required. These blends are capable of dissipating an amount of energy sufficient to ensure proper adhesion between the tread band and the ground.

It is important to remember that the temperature reached by the elastomeric blend in operation is proportional to the amount of dissipated energy, and therefore to its hysteresis value. As a result, an optimal elastomeric compound forming the tread band should have quite opposite hysteresis behaviors, incompatible with each other, to simultaneously optimize all desired performance features of the tyre.

So far, attempts carried out in the art to improve tyre performance in a temperature range different from the temperatures of normal use have resulted in either a large and undesired loss of grip, or in a significant worsening in the resistance to abrasion of the tread band. In some cases, both drawbacks were present.

Pirelli in the past has also tried to solve this problem, in particular with a tyre being the object of Italian Patent No. 1,087,461 to its name. The tyre described in that patent is provided with a tread band consisting of two axially contiguous circumferential portions of different composition, the first portion of which is made of an elastomeric blend having a low glass-transition temperature (referred to as "Tg"), included between -55°C and -30°C, whereas the

blend of the second portion has a higher Tg, included between -25°C and -10°C. Although some advantages were achieved under conditions of normal or high operating temperatures, under winter conditions when the tyre is subject to low environmental temperatures close to the temperature of the highest Tg (-10°C), the tyre showed a significant decay in its operational performance.

In view of the above, the described problem appears to be substantially unsolved by the known art. In particular, tyre tread bands of known type cannot maintain the same grip when the tyre, under extreme use conditions, exceeds the above mentioned standard temperatures of use (30°-50°C), without, on the other hand, simultaneously losing their resistance to abrasion.

BRIEF SUMMARY OF THE INVENTION

In accordance with the present invention, it has been unexpectedly found that it is possible to retain the tyre performance existing under normal conditions, while improving such performance to a higher level during tyre use under extreme conditions.

Applicants approached the problem of producing tyres with tread bands of different material while developing a tyre having colored inserts, such as for example a white sidewall, and in particular tyres with a tread band of two distinct colors. A two-colored tyre, in addition to having an agreeable and unusual aesthetic aspect which enables car personalization by an owner with his/her preferred colors, may also have more practical functions such as enabling a correct mounting orientation of the tyre on the vehicle when required, or an immediate identification of the type of tyre stored among a great number of other types in a warehouse that may be poorly illuminated.

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Applicants realized that making colored elastomeric blends excludes the use, even in minimum proportions, of carbon black as a reinforcing filler, because carbon black has such a coloring power that the effect of any other colored pigment is drowned out.

Only so-called "white" fillers can be colored with appropriate pigments. Among these, the preferred fillers for use in tyres, especially in the tread band region, have been identified as fillers of siliceous material, in particular silica.

It is known that silica is useful for giving the tyre qualities of low rolling resistance, due to the low hysteresis value of the silica filled elastomeric blend, and good grip on snow-covered or wet ground. Silica, however, offers lower performance regarding grip on a dry ground and resistance to wear, so that its use as a reinforcing filler in the tyre tread band must be carefully controlled.

Applicants observed the results of road tests of a series of prototypes having the tread band consisting of two different circumferential portions located axially side-by-side, one portion consisting of an elastomeric blend mainly filled with carbon black (black blend) and the other consisting of a blend exclusively filled with white filler (white blend). Applicants ascertained that the performance on a dry road of those tyre prototypes were always globally better than those of the groups of control tyres, having respectively the tread band made of a blend filled with carbon black, or with a very high percentage of silica.

While conducting studies to clarify the reasons of these unexpected results, Applicants carried out some thermographies of the tread band of tyres being tested, thus finding out that the two-colored tyres according to the invention tended to operate at a lower temperature than the black tread tyres. In particular, even the black tread portion of those prototypes operated at a

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lower temperature than the equivalent tread portion in the tyres with a completely black blend tread band.

The improvement achieved in accordance with the present invention in the road behavior of two-colored tyres, as compared with conventional tyres, is believed to result from the lower operating temperature of the tyre. The improvement achieved relative to white tyres depends on the above mentioned and known deficiencies typical of silica filled elastomeric compounds in connection with important aspects of the tyre performance on the road.

In particular, the white blend portion, or in any case the portion formed of a low-hysteresis blend that is a "cold" operating blend, in tyres provided with a two-blend tread band is deemed to generate a synergetic action linked to its lower operating temperature. This synergy tends to keep the adjacent tread band portion formed of a black blend colder than in a conventional design, in addition to keeping the overall tread band colder.

The invention is considered capable of carrying out its effects in a perceptible manner when differences between the hysteresis values and/or the white filler amounts in the two elastomeric blends used in the tread band are preferably included within given limits, as more specifically described below.

In accordance with a first aspect of the present invention, a method has been found of controlling the working temperature of a tyre comprising a toroidal carcass provided with axially opposite sidewalls and beads for anchoring to a corresponding mounting rim, a tread band located circumferentially on the crown portion of said carcass and molded with a raised pattern for rolling contact with the ground, and a belt structure interposed between said carcass and tread band, axially extending in a continuous manner between said sidewalls. The method consists in making the tread band of at least two circumferential and axially contiguous portions, a first

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portion and a second portion respectively of different compositions, which compositions have a different hysteresis value. The difference between said two hysteresis values results in a working temperature of the tyre which is lower, as a whole, than the temperature of a conventional tyre with a tread band made of the composition having the greater hysteresis value.

It has been found that preferably the difference between said hysteresis values must be at least equal to 10% of the higher value, and preferably greater than 20% of said higher value.

In accordance with a different aspect of the invention, it has been found that an alternative method may be carried out by making the tyre tread band of two circumferential portions, located axially in side-by-side relationship, from different compositions. The compositions are respectively a white one and a black one. At least one of the compositions comprises a white filler as the reinforcing filler. The difference between the amount of white filler present in each of the two compositions is selected to obtain an operating temperature of the tyre which, as a whole, is lower than the operating temperature of a tyre having a tread band made only of the composition containing the lower amount of white filler.

It has been found that the so-called black composition must preferably contain at least 40%-by-weight of carbon black, whereas the so-called white composition must contain at least 20%-by-weight of white filler, relative to the total amount of reinforcing filler. More specifically, the white blend must contain an amount of white filler, in terms of filler weight, greater than the amount contained in the black blend. The filler amount difference between the two blends must preferably correspond to a percent difference of at least 20% between the percentages-by-weight of white filler out of a total amount of the reinforcing filler in each of the two blends.

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In a different aspect the invention relates to a tyre for vehicle wheels comprising a toroidal carcass provided with axially opposite sidewalls and beads for anchoring of said tyre to a corresponding mounting rim, a tread band placed crownwise to said carcass. The tread band comprises a plurality of hollows and grooves variously located relative to the equatorial plane of the tyre, adapted to define a raised tread pattern for rolling contact with the ground. A belt structure is interposed between said carcass and tread band, axially extending in a continuous manner between said sidewalls. The tread band is formed of at least two circumferential and axially contiguous portions, a first portion and a second portion respectively, formed of different compositions of elastomeric compounds, characterized in that said compositions have different hysteresis values. The difference between said two hysteresis values is selected to obtain a working temperature in the tyre which is lower, as a whole, than the working temperature of a tyre having a tread band made only of the composition showing the greater hysteresis value.

In a further aspect, the invention relates to a tyre for vehicle wheels comprising a toroidal carcass provided with axially opposite sidewalls and beads for anchoring the tyre to a corresponding mounting rim, a tread band located crownwise to said carcass comprising a plurality of hollows and grooves variously located relative to the equatorial plane, adapted to define a raised tread pattern for rolling contact with the ground, and a belt structure interposed between said carcass and tread band, axially extending in a continuous manner between said sidewalls. The tread band is formed of at least two circumferential and axially contiguous portions, a first portion and a second portion respectively, formed of different compositions. The first portion comprises a reinforcing filler of carbon black including at least 40%-by-weight of said carbon black, and the second portion comprises a white reinforcing filler in an amount at least equal to 20%-by-weight of the total amount of reinforcing filler in the elastomeric

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composition of the second portion. The composition difference between the two portions is selected to obtain a working temperature in the tyre that, taken as a whole, is lower than the temperature of operation reached by a tyre with a tread band made only of the composition containing the lower amount of white filler.

It has been found preferable for the second portion to contain the greater amount of white filler, and for the difference between the amounts of said white filler present in the compositions of the two portions to be at least equal to 20%-by-weight in favor of the second or "white" portion, provided that the volume of white filler in said second portion is such that the decrease in operating temperature described above is obtained.

In accordance with the invention, it has been found preferable for the volume of said second portion to be at least as high as 30% but not higher than 80% of the overall volume of the tread band. In a further different aspect of the invention it has been found preferable for the axial width of said second portion to be at least as high as 25% but not higher than 80% of the overall width of the tread band, and preferably greater than 50%.

In a further novel and still different aspect, the invention is a tread band that can be made of raw blend or of an already pre-molded blend, for use in covering or "recapping" worn tyres. The tread band can then be made according to any one of the above mentioned different alternative embodiments.

In another and still different aspect, the invention also relates to a method of producing tyres for vehicle wheels, and specifically tread bands for said tyres having colored inserts of colors different from black.

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BRIEF DESCRIPTION OF THE DRAWINGS

The file of this patent contains at least one drawing executed in color. Copies of this patent with color drawing(s) will be provided by the Patent and Trademark Office upon request and payment of the necessary fee.

Fig. 1 is an axial transverse section of a tyre of the type used in four-wheeled vehicles, in accordance with one embodiment of the invention;

Fig. 2 is an axial transverse section of a tyre of the type used in two-wheeled vehicles, in accordance with another embodiment of the invention;

Fig. 3 is a plan view of a portion of tread band in accordance with the invention, showing a tread pattern of the symmetric type;

Fig. 4 is a front view of a tyre with a tread band in accordance with the invention, showing a tread pattern of the asymmetric type;

Fig. 5 is a plan view of a portion of tread band in accordance with the invention showing a tread pattern of the directional type; and

Fig. 6 is a color thermograph of a tyre tread in accordance with the invention compared with that of a tyre of known type, referred to the same tread pattern, of the asymmetric type, under the same working conditions.

DETAILED DESCRIPTION OF THE ~~INVENTION~~ Exemplary Embodiments

Fig. 1 shows the structure of the inventive tyre in an embodiment used in four-wheeled vehicles. Such structure other than the tread band does not differ substantially from the general structure of traditional tyres, however the differences with the latter will become apparent in the following description.

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Tyre 1 comprises a carcass 2 of a strong structure formed of at least one ply 3 of rubberized fabric comprising reinforcing cords of textile or metal material buried into the elastomer material of the fabric, said ply having its ends 3a each turned up about an anchoring ring or bead 4. The bead core is provided on its radially outer surface with a rubber filling 5. Preferably the turned-up flaps 3a of the carcass plies extend up radially outwardly along at least part of the side of said filling.

As known, the tyre area comprising bead core 4 and filling 5, that is the radially inner portion of the tyre sidewall, forms the tyre bead which is intended for anchoring of the tyre to a corresponding mounting rim.

Located in known manner on the carcass, which is preferably of the radial type having the reinforcing cords lying in planes along the tyre axis of rotation, there is a tread band 10, provided with a raised pattern intended for rolling contact of the tyre on the ground. The width L of this band is identified by the distance between the intersection points of the tread band and sidewall curvatures, referred to as the edges of the tread band.

This tread pattern may be comprised of a plurality of ribs and/or blocks 11, 12 separated from each other by corresponding hollows and grooves 13, 14, directed both circumferentially and transversely. Said ribs and/or blocks may be provided with various cuts and narrow slits or "lamellae" 15, forming configurations well known to those skilled in the art.

Tyre 1 may also be comprised of a belt structure 6 located crownwise on carcass 2, interposed between the carcass and tread band, extending from one side to the other side of the tyre, i.e., substantially as wide as the tread band, and comprising two radially superposed layers 7, 8 of reinforcing cords. The reinforcing cords are preferably of metal material and are parallel to each other in each layer, but are located in crossed relationship with those cords of the

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adjacent layer relative to the equatorial plane of the tyre. In a preferred embodiment, a further radially outermost layer 9 of reinforcing cords, preferably of textile material, and more preferably of a heat-shrinkable material (nylon) oriented at 0° relative to a circumferential direction, is located between the tread band and the radially more internal belt layers.

In accordance with the invention, the tread band is formed of two circumferential portions, a first (hot) portion A and a second (cold) portion B respectively, which are axially contiguous and made up of different compositions. More specifically, said two compositions have a different hysteresis value, and the difference between the two values is such that it causes each portion, during the tyre operation, to operate at a different temperature. Preferably, the hysteresis difference must be at least equal to 10% of the higher hysteresis value, and more preferably greater than 20% of said value.

The hysteresis value to which reference is made above is the loss factor (tan δ) measured on a cylindrical test piece of 14 mm diameter and 25 mm length, tested under the following conditions: temperature of 70°C, deformation frequency equal to 100 Hz in a sinusoidal condition, on a 25%-precompressed test piece submitted to a further deformation width of 3.5% relative to the size of the undeformed test piece.

It is preferable for the test piece to be submitted in known manner, before measurement, to a conditioning cycle in terms of time and frequency cycles, so as to stabilize data of the subsequent measurement. Said test piece may be also obtained from several suitably-superposed slices of reduced thickness that, for example, can be removed from parts of the tyre tread.

In an alternative embodiment, the two circumferential portions comprise a first (black) portion A and a second (white) portion B. More specifically, said two portions are made of elastomeric compositions that have different reinforcing fillers, including a white filler. The

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difference between the amount of white filler present in the A and the B portions is at least equal to 20% of the amount present in the white portion.

It has been found that preferably the black composition must contain at least 40%-by-weight of carbon black, whereas the white composition must contain at least 20%-by-weight of white filler, measured relative to the total amount of the reinforcing filler in the respective elastomeric composition mixtures. The two compositions have a difference in amount of white filler contained that is at least equal to 20%-by-weight, with the white composition having more of the white filler.

It has been found that the invention accomplishes its goals in a particularly appreciable manner when the volume of the second portion B, i.e., that of the cold or white composition, is such that the overall operating temperature of the tyre is reduced relative to a reference temperature. The reference temperature can be either the operating temperature of an equivalent tyre submitted to the same operating conditions but provided with a tread made entirely of the cold composition having a greater hysteresis value or, alternatively, of an equivalent tyre provided with a tread made entirely of the black composition having the smaller amount of white filler and lower hysteresis value.

More specifically, it has been found that when the volume of said second portion B represents a significant percentage of the overall volume of the tread band, the operating temperature of both the entire tread band and of each separate blend portion, as well as of all the tyre taken as a whole, remains lower than the reference temperature of an equivalent tyre having the tread band made entirely of the black, or hot, elastomeric composition. By "equivalent tyre" it is herein intended a tyre identical to the tyre according to the invention, except for the different elastomeric composition forming the tread band.

It has been found that in a tyre formed according to the invention, the decrease in the overall operating temperature of the tyre, i.e., the inner temperature of the tyre, is on the order of at least 5°C or more, relative to an equivalent tyre.

In accordance with the invention, a "significant percentage" of the overall volume of the tread band is deemed to mean an amount at least as high as 30% of the overall volume of said tread band, and preferably higher than 50%. This percentage indicates how much of the tread band is formed by an elastomeric compound having the higher proportion of white filler. On the other hand, increasing this percentage reduces the tread resistance to wear and increases grip loss, so that in order to maintain the good performance qualities achieved by the tyre of the invention, the volume of this second portion B of the tread band should not exceed 80% of the overall volume of said tread band.

The ideal relative volume of the two tread band portions also depends on the features of the pattern formed thereon, and in particular on the ratio between lands and hollows. This ratio is generally different between the two portions in the case of asymmetric patterns, so that the width of the second portion, i.e., the so-called cold or white portion, is preferably included between 25% and 80% of the overall width of the tread band, and more preferably greater than 50% of said width.

In another preferred embodiment of the invention designed to provide a colored composition, in the second portion B the white filler is preferably used in an exclusive manner as the reinforcing filler. In other words, the second portion B preferably forms a colored insert substantially devoid of carbon black. In accordance with the invention, this coloring of the second portion is preferably obtained by mixing the white filler with coloring pigments selected from a wide variety of possible colors. Many suppliers can provide these coloring agents and

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compositions containing an already colored white filler. Applicants selected the material available from the Italian associated firm CLARIANT to assemble a tyre according to the invention.

With reference to the blends used in the invention, it is to note that carbon black for the reinforcing filler is known in the art. Applicants preferably uses carbon black having an absorption value DBP measured following ISO 4656-1 standards equal to at least 100 ml/100 g, preferably included between 130 ml/100 g and 160 ml/100 g, and a surface area as determined based on cetyltrimethylammonium absorption according to ISO 6810 standards (CTAB) not exceeding 130 m^2/g, and preferably included between 70 m^2/g and 115 m^2/g.

The so-called "white" fillers, for example, are reinforcing fillers of inorganic type such as gypsum, talc, kaolin, bentonite, titanium dioxide, silicates of various kinds, and silica. Preferably the white blend of the invention comprises a silica-based white filler that is a reinforcing agent based on silicon dioxide (silica), silicates, and mixtures thereof having a surface area measured according to BET method following ISO 5794-1 standard included between 70 m^2/g and 300 m^2/g, and an appropriate binding agent capable of chemically reacting with silica and bonding silica with a polymeric base during vulcanization. Among the great number of available binders, Applicants have found it convenient to use a known silane binding agent, identified as Si69, available from DEGUSSA.

With regard to the polymeric base of the blends in accordance with the invention, it can be selected from the group comprising: natural rubber, 1,4-cis polybutadiene, polychloroprene, 1,4-bis polyisoprene, optionally halogenated isobutene-isoprene copolymers, butadiene-acrylonitrile, styrene-butadiene copolymers and styrene-butadiene-isoprene terpolymers, obtained both in solution and in emulsion, and ethylene-propylene-diene terpolymers. In

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accordance with the invention, these polymeric bases can be used individually or in a mixture thereof in accordance with the features that are wished to be imparted to the finished product.

By way of example only and not in a limiting sense, two examples of compositions are given hereinafter for the black blend and the white blend respectively, that may be used for tyres in accordance with the invention.

The elastomeric composition of portion A, in the version with a reinforcing filler exclusively of carbon black, may have the following composition, set forth in parts-by-weight:

-	polymeric base	100.0
-	carbon black	68.0
-	ZnO	2.0
-	stearic acid	1.0
-	antioxidants	2.5
-	anti-fatigue agents	1.0
-	plasticizers	15
-	sulphur	1.2
-	accelerating agents	1.8

The elastomeric composition of portion B, in the version including only said silica-based white filler as the reinforcing filler, may have the following composition, set forth in parts-by-weight:

-	polymeric base	100
-	silica	70
-	binding agent	8% of silica

-	ZnO	2
-	stearic acid	1
-	antioxidants	2.5
-	anti-fatigue agents	1
-	plasticizers	15
-	sulphur	1.2
-	accelerating agents	2.5

For achievement of the results of the invention, said second portion B may be located either in the central area of the tread band, flanked on both sides by portions A, as shown in Fig. 5, or at a side position on the tread band, adjacent an edge of the tread band, as shown in Fig. 4. However, due to the fact that the second portion B is more sensitive to wear and to grip loss than the first portion A, the most convenient position for the second portion B, at least for tyres used in situations that are not extremely demanding, is near the inner edge of the tread band, nearest to the vehicle centerline when the tyre is mounted on the vehicle, where stress is lower during operation of the tyre. In high-performance tyres or tyres used in extremely demanding conditions, the centre position will be the preferred one when symmetric and directional tread patterns are utilized, while the side position will be the preferred one for asymmetric patterns. Actually, such asymmetric tread patterns also have two axially distinct circumferential areas with reference to mounting of the tyre on the vehicle, an inner area nearer the vehicle centerline and an outer area further from the vehicle centerline, respectively. In this case, said second portion B is preferably situated at the inner area of the pattern, that is the one which is located nearer the vehicle centerline.

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Use of a compound portion reinforced with a white filler, as already described, also enables a convenient coloring of this portion. As explained, it is apparent that it may be difficult to visually mount a tyre with a symmetric or directional tread pattern made only of black tread band compound, so that the portion to be mounted on the vehicle side is in the correct orientation. It is therefore apparent that by differently coloring inserts corresponding to different tread portions, this mounting problem too can be solved.

The invention can also be advantageously applied to tyres for motorcycles. These tyres (Fig. 2) are distinguished by a high transverse curvature, identified by the value of the ratio of the distance ht of the tread centre from line b passing through the tread ends C-C, measured on the equatorial plane, to the distance wt between said tread ends C-C. This value, generally greater than 0.15:1 in tyres for front wheels, is often even greater than 0.30:1 as compared to an usual value in tyres for cars on the order of 0.05:1. Throughout the present description said ratio will be referred to as "curvature ratio." In motorcycle tyres, according to the present invention, the tread width must be interpreted as a measurement of the tread extension along its curvature profile.

Fig. 2 generally shows a motorcycle tyre of this type, comprising a very particular geometry structure capable of withstanding very particular use conditions. As is known, two-wheeled vehicles in covering a curvilinear trajectory lean toward the internal side of the turn by an angle referred to as "camber angle," the value of which can reach 65° relative to a plane vertical to the ground.

In this motorcycle tyre, a carcass structure which is substantially identical to that previously described is provided. The same reference numerals as shown in Fig. 1 have been also used here. However, in this case the belt structure 6 comprises a reinforcing wrapping

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which is an essential element, and consists of at least a preferably metallic inextensible cord 9 reaching circumferentially crownwise to the carcass ply 3 to form a plurality of turns 9a parallel to each other and located consecutively in side-by-side relationship, substantially oriented along the rolling direction of the tyre 1. The radially underlying layers 7, 8 of inclined cords are optional.

Turns 9a are located consecutively in side-by-side relationship along a curvilinear profile, and by virtue of their substantial longitudinal inextensibility, structurally and dimensionally stabilize tyre 1 to maintain the desired transverse-curvature profile.

In accordance with the invention, the tread band 10 is conveniently formed of said portions A and B made of different elastomeric compounds. The cold or white blend portion B is preferably located on either side of the equatorial plane of the tyre for reasons of structural and operating symmetry of the tyre, due to its particular geometric shape and the operating conditions of the leaning vehicle in a turn. In other respects, the same considerations, restrictions, and critical values already mentioned above are also valid for this type of tyre.

Fig. 3 shows a plan view of a portion of tread band for a tyre according to the invention, molded with a known tread pattern of the symmetric type. With regard to these pattern types, disposition of the white blend portion B can take place in any desired manner, both at a side position relative to the tread band or at a centre position in a central area of the tread band. In a preferred embodiment shown in Fig. 3, portion B is shown in cross-hatching and is located at a central position, extending axially from the equatorial plane of the tyre. In connection with particular technical requirements or for other reasons to be met, said portion B can be located either on one or both of the shown band sides 11, on either side of the equatorial plane, or can be divided into a plurality of circumferential areas alternating with black blend areas.

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Fig. 4 is a front view of a tyre provided with a tread band in accordance with the invention, molded with a tread pattern of the asymmetric type which has an inner circumferential area I located axially in side-by-side relationship with another outer circumferential area E.

As described above, the tyre is mounted on the vehicle so that area I is located near the vehicle centerline and area E is located further away from the vehicle. With this asymmetric type, the white blend portion B (in cross-hatching) is preferably located in a side portion of the tread band and, most preferably, on the inner side area I.

Fig. 5 is a plan view of a portion of the tread band of a tyre embodiment according to the invention, molded with a tread pattern of the directional type. In this pattern, the white blend portion B (in cross-hatching) will preferably be located in a central position and, most preferably, on either side of the equatorial plane of the tyre.

The performance of the tyre according to the invention has been analyzed under operating conditions, with that of an equivalent black tyre taken as a reference, by adopting a particular technique known as tyre thermography. In this technique, tyres to be compared are driven in rotation by friction against a drum rotating at a predetermined speed. Applicants have used a drum of 1700 mm diameter, rotated at a speed equivalent to 120 km/hour. Tyres are mounted to the recommended rim for operation, inflated to a pressure approaching the operating pressure, and pressed against the drum with a load corresponding to about the rated running load of the tyre, as provided by E.T.R.T.O. (European Tyre and Rim Technical Organization) regulations.

After a time lag varying between 30 and 60 minutes, depending on the tyre size, the carcass structure, the tread pattern, and the ambient temperature, it appeared that the inner (overall) temperature of the tyre reached a stable value. At that time the tread was

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thermographically photographed using infrared light. The thermography photographs can be carried out both with the tyre at a standstill and with the tyre in rotation, the modality being selected by the experimenter depending on the specific requirements. The result in either case is an image of the tyre tread that can be conveniently reproduced in colors or on a grey-scale, in which the different colors or grey shades identify, spot by spot, the different tread temperatures, both on the surface of the tread and at the bottom of the tread grooves.

Fig. 6 is a color thermograph of a prototype tyre tread compared with a tyre tread of conventional production manufactured by Pirelli. The conventional tyre is quite similar to the prototype tyre, apart from the fact that the conventional tyre tread band is completely made of a black blend.

On the chromatic scale selected by the Applicants, color changes from blue to red, passing through sky-blue, green, and yellow, as the temperature increases from 25°C to 65°C.

The photographed tyres are the tyre of the invention, to the right in Fig. 6, provided with a black/white two-blend band having the white portion to the right, compared with Pirelli tyre "P 200 CHRONO ENERGY" of conventional production, to the left in Fig. 6.

The tested tyres had size 175/70R13, were mounted to a rim type J 5.5", inflated to a pressure of 2.2 bars, and submitted to a load of 450 kg.

The compound blends of the two portions used in the tire according to the invention had compositions set forth in the following Table 1:

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TABLE 1

Ingredient	Black Blend	White Blend
SBR 1712	80	
SBR 1500	20	
OE-SSBR		80
BR		33
Carbon Black - N 220	45	
Silica - VN3 available from DEGUSSA	20	70
Binding Agent	1.6	5.6
ZnO	2.5	2.5
Stearic Acid	2	2
Antioxidants	1.5	1.5
Anti-fatigue Agents	1	1
Plasticizers	10	5
Sulphur	1	1.4
Accelerating Agents	2.3	3.8

From Fig. 6 one can easily see that in the tyre made according to the invention the colder sky-blue portion indicating 35°C occupies a remarkably greater area than that of the reference tyre, where the warmer green portion indicating 45°C is prevalent. The colder area also extends further towards the left tyre shoulder made of black blend in the two-blend tyre, when compared to the corresponding portion of the reference tyre.

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Measurements of the inner (overall) temperature of the tyre have given a value of 53°C for the tyre according to the invention, as compared to a value of 58°C for the reference tyre.

Results achieved from different comparative road tests carried out with the above tyres are reproduced in the following Table 2. More particularly, column 1 of Table 2 refers to the test results achieved with tyre "P 200 CHRONO ENERGY," and column 2 of the Table refers to results of a tyre according to the invention. Both tyres were mounted on a VOLKSWAGON POLO 1.4 car. Said Table 2 reproduces the results achieved in performance tests on a mixed route including one portion on a normal road and one portion on a car track, on a dry road surface, at an ambient temperature of 14°C.

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TABLE 2

Performance	Tyres 1	Tyres 2
Running on a straight run		
Directional stability	6.5	6.5
Steering rigidity	6.5	6.5
Fast run		
Empty on the centre	6.0	6.5
Steering response speed	6.5	7.0
Steering response progressivity	5.5	6.0
Directional stability on a bend	6.5	6.5
Realignment	5.5	6.5
Extreme Conditions		
Yield	7.0	7.0
Release on bends	6.5	7.0
Controllability	7.0	7.0

The assigned points indicate the score obtained by the corresponding tyres, on a 1 to 10 scale, based on the test driver's judgment, with reference to the different tyre qualities taken into account in the test. The greater scores indicate better performance.

As one can see from Table 2, the qualities of the tyre according to the invention are substantially identical to those of the conventional tyre under normal operating conditions on a straight run, when the tread blend is not particularly under stress. On the contrary, the tyre

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according to the invention performs much better with increased employment severity and increasingly stressful conditions to which the tread blend is submitted. Particularly, when the heat generated in the tyre increased so that the temperature reached by the tread increased, the performance of the tyre according to the invention also improved, especially with respect to traction. Actually, from Table 2 one can note that the tyre according to the invention has obtained a score higher than that of the reference tyre from every point of view.

It is therefore apparent that the present invention has enabled the desired improvements to be achieved by a synergetic combination between distinct tread band portions, made of a black (hot) blend and a white (cold) blend respectively, so that an exclusively positive overall result is obtained, that is equal to or better than the results obtained by conventional tyres, seen from any measure of tyre performance on a road.

It is also clear that the invention has provided a convenient method of reducing the operating temperature of the tyres while simultaneously safeguarding all required performance qualities. In particular, it is still more evident how the invention can achieve excellent results with reference to recapped tyres, where adhesion between the already vulcanized old carcass and the new, raw, or pre-molded tread band has always represented a particularly critical element due to its sensitivity to the operating temperature of the tyre, as proved by the separated tread pieces that can be found on motorways.

Finally, it is apparent that the present invention description only has an explanatory function and not a limiting function, so that a person skilled in the art, after understanding the invention as above described will be able to carry out modifications, variations, and replacements of all variables associated with the present invention in order to meet particular and contingent application requirements, depending on needs.

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